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# Photovoltaic Charge Controller Using Mppt Algorithm

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***Abstract*— The main aim is to design a simple but effective charge controller with maximum power point tracking to provide higher efficiency and to protect the battery from getting damaged. Implementing a MPPT algorithm in charge controller is necessary because the current-voltage characteristics of solar PV arrays are non-linear where at a particular point the power output is max. So to extract the maximum power from the solar PV system, implementation of MPPT algorithm is must.**

***Index Terms*— Charge controller, Cuk converter, MPPT Algorithm, Photovoltaic cell**

## I. INTRODUCTION

The past few years have been filled with news of fuel price hikes, oil spills, and concerns of global warming. One of the few positives that can be taken from this is that it is changing the average person's mindset towards renewable energy. The biggest form of renewable energy to benefit from this is solar energy. Solar energy is plentiful; it has the greatest availability compared to other energy sources. Solar energy is clean and free of emissions, since it does not produce pollutants or by products harmful to nature. The conversion of solar energy into electrical energy has many application fields. Solar energy is much greater than any other renewable and fossil fuel based energy resources. Photovoltaic is the direct process of converting solar energy into electricity. It is considered as a clean and environmentally-friendly source of energy.

However, PV generation systems have two major problems which are related to low conversion efficiency especially in low irradiation conditions and the amount of electric power generated by PV arrays varies continuously with weather conditions. Therefore, many research works are done to increase the efficiency of the energy produced from the PV arrays.

Considering the high initial installation cost of the PV system, it is always necessary to operate PV at its Maximum Power Point (MPP). For this purpose buck-boost converter interface is required between PV and battery. The buck-boost converter amplifies or attenuates the output voltage of solar cell to a level required by the load.

If a battery is connected in place of load, and if the voltage applied to this is not maintained constant at the charging level then it may affect batteries duty cycle. It may even lead to permanent damage of battery. Hence proper charge controller is required to avoid the damage of battery and to provide higher efficiency rate.

The main function of the charge controller is to fully charge the battery by maintaining a constant battery input voltage and to avoid the overcharging of the battery, which may also damage the battery permanently.

## II. BLOCK DIAGRAM

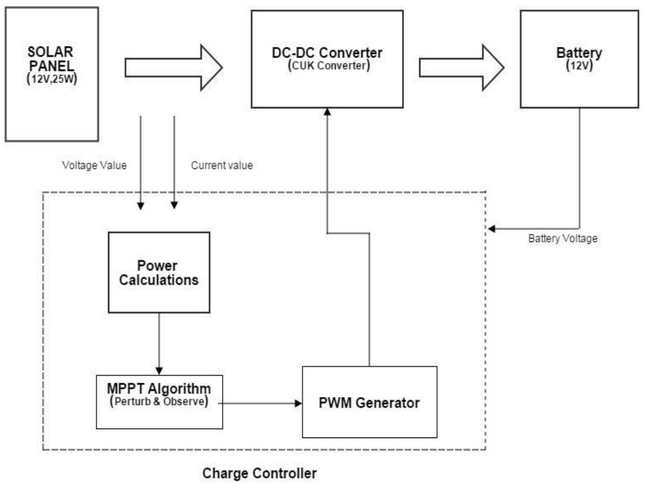


Fig. 1 Basic Block Diagram

A) Solar Panel:

A solar panel is a packaged connected assembly o f photovoltaic cells. It mainly works on photovoltaic effect. It uses light energy from the sun to generate electricity through the photovoltaic effect. The majority of modules use silicon wafer based cells to convert light energy into electricity.

The advantages of solar panels are,
- They use the most readily available solar energy.
- They can easily last for 25 years.
- It does not require much maintenance.

Following are the open circuit output voltage readings of a 12V, 20W solar panel.

| Time | Voc |
|---|---|
| 10.00 am | 13.68 V |
| 10.30 am | 20.20 V |
| 11.00 am | 19.60 V |
| 12.00 | 19.00 V |
| 01.00 pm | 18.40 V |
| 02.00 pm | 18.12 V |
| 03.00 pm | 17.30 V |

Table.1 Op en circuit voltage of a solar panel

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B) Charge Controller

A charge controller limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and prevent against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. In simple words, solar charge controller is a device, which controls the battery charging from solar cell and also controls the battery drain by load. The simple solar charge controller checks the battery whether it requires charging and if yes it checks the availability of solar power and starts charging the battery. Whenever controller found that the battery is fully charged, it then cuts down the supply to the battery.

The functions of a microcontroller in charge controller are:

- Measures Solar Cell Voltage.

- Measures Battery Voltage.

- Decides when to s tart battery charging.

- Decides when to s top battery charging.

-Depending upon the solar voltage it generates equivalent value of PWM and gives it to DC-DC converter.

C) DC-DC Converter:

DC-DC converters are electronic devices used whenever we want to change DC electrical power efficiently from one voltage level to another. They are needed because unlike AC, DC can't simply be stepped up or down using a transformer. In many ways, a DC-DC converter is the DC equivalent of a transformer. The key ingredient of MPPT hardware is a DC-DC converter.

## III. MAXIMUM POWER POINT TRACKER

The weather and load changes cause the operation of a PV system to vary almost all the times. A dynamic tracking technique is important to ensure maximum power is obtained from the photovoltaic arrays. This unique point is the maximum power point (MPP) of solar panel. Because of the photovoltaic nature of solar panels, their current-voltage curves depend on temperature and irradiance levels.

Therefore, the operating current and voltage which maximize power output will change with environmental conditions. As the optimum point changes with the natural conditions so it is very important to track the maximum power point (MPP) for a successful PV system.

Perturb and Observe method (P&O)

In this method the controller adjusts the voltage by a small amount from the array and measures power, if the power increases, further adjustments in the direction are tried until power no longer increases, this is called P&O method. Due to ease of implementation it is the most commonly used MPPT method.

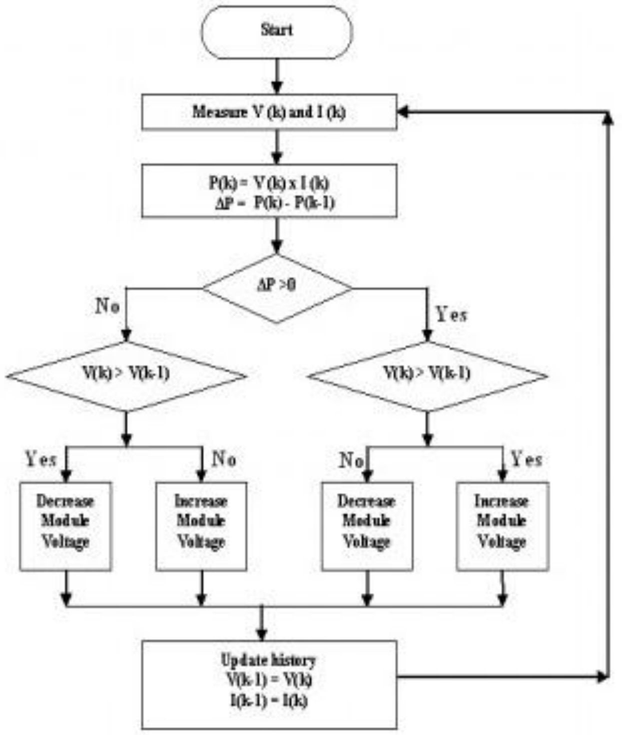


Fig.2 P&O algorithm

The first step in the P&O algorithm is to sense the current and voltage presently being output by the PV panel and use these values to calculate the power being output by the panel. The algorithm then compares the current power against the power from the previous iteration that has been stored in memory. If the algorithm is just in the first iteration the current power will be compared against some constant placed in the algorithm during programming. The system compares the difference between current and previous powers against a predefined constant. This constant is placed within the algorithm to ensure that when the method has found the MPP of the PV panel, the duty cycle will remain constant until the conditions change enough to change the location of the MPP. If this step is not included the algorithm would change the duty cycle, causing the operating point of the panel to move back and forth across the MPP.

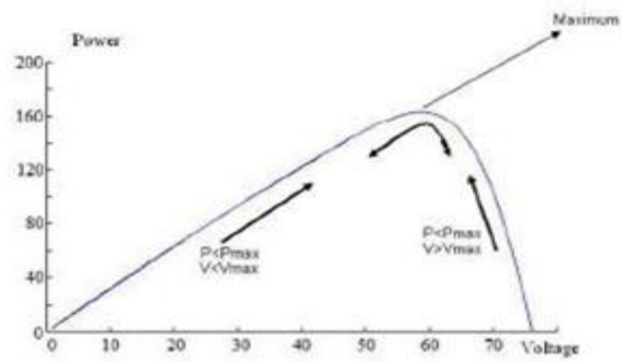


Fig.3 P-V curve of solar panel

The voltage to a cell is increased initially, if the output power increase, the voltage is continually increased until the output power starts decreasing. Once the output power starts decreasing, the voltage to the cell decreased until maximum power is reached. This process is continued until the MPPT is attained. This result is an oscillation of the output power around the MPP. PV module's output power curve as a function of voltage (P-V curve), at the constant irradiance and the constant module temperature, assuming the PV module is operating at a point which is away from the MPP. In this algorithm the operating voltage of the PV module is perturbed by a small increment, and the resulting change of power, P is observed. If the P is positive, then it is supposed that it has moved the operating point closer to the MPP. Thus further voltage perturbations in the same direction should move the operating point toward the MPP. If the P is negative, the operating point has moved away from the MPP, and the direction of perturbation should be reversed to move back toward the MPP.

## IV. DC TO DC CONVERTER

Cuk converter

To obtain a stable voltage from an input supply (PV cells) that is higher and lower than the output, a high efficiency and minimum ripple DC-DC converter required in the system for residential power production. Cuk converters make it possible to efficiently convert a DC voltage to either a lower or higher voltage. Cuk converters are especially useful for PV maximum power tracking purposes, where the objective is to draw maximum possible power from solar panels at all times, regardless of the load.

Circuit Description and Operation:

The Cuk converter is obtained by using the duality principle on the circuit of a buck-boost converter. Similar to the buck-boost converter, the Cuk converter provides a negative polarity regulated output voltage with respect to the common terminal of the input voltage. The output voltage magnitude can be same, larger or smaller than the input, depending on the duty cycle. The inductor on the input acts as a filter for the dc supply, to prevent large harmonic content.
Here, the capacitor C1 acts as the primary means storing and transferring energy from the input to the output.

In steady state, the average inductor voltages VL1 an d VL2 are zero.

$$V_{c1} = V_s + V_o$$

Therefore, VC1 is larger than both Vs and Vo. Assuming C1 to be sufficiently large, in steady state the variation in VC1 from its average value VC1 can be assumed to be negligibly small (VC1≈vC1), even though it stores and transfers energy from the input to the output .

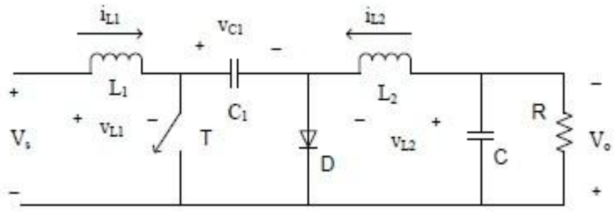

Fig.4 Cuk Converter

When the switch is off, the inductor currents iL1 and iL2 flow through the diode. Capacitor C1 is charged through the diode. The circuit is shown in Figure 4, Capacitor C1 is charged through the diode by energy from both the input and L1. Current iL1 decreases because VC1 is larger than Vs. Energy stored in feeds the output. Therefore iL2 also decreases.

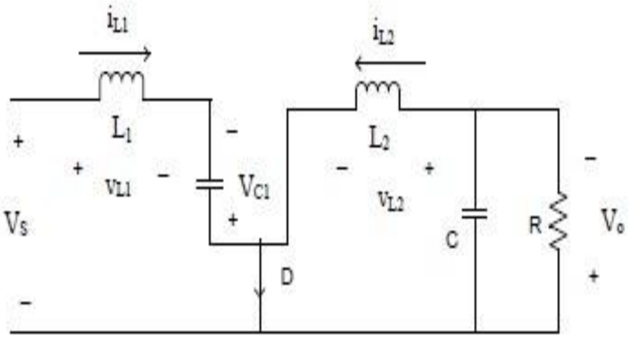

Fig.5 voltage and current of cuk converter when switched-off

When the switch is on, VC1 reverse biases the diode. The inductor currents iL1 and iL2 flow through the switch as shown in Figure 5. Since VC1>Vo, C1 discharges through the switch, transferring energy to the output and L2. Therefore iL2 increases the input feeds energy to L1 causing iL1 to increase.

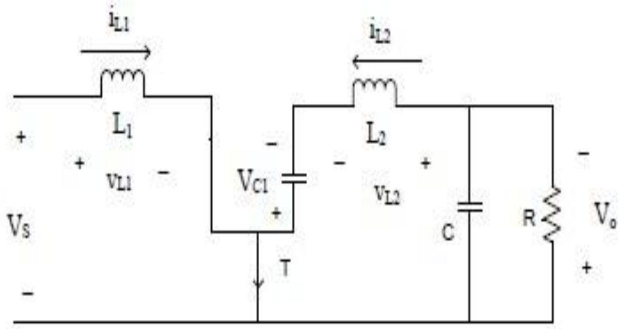

Fig.6 voltage and current of cuk converter when switched-on

The inductor currents iL1 and iL2 are assumed to be continuous.

Output voltage relation with Duty Cycle
If 0<*D*< 50 % the output is smaller than the input.
If *D* = 50 % the output is the same as the input.
If 50 %<*D*<100 % the output is larger than the input.

From the simulation and implementation parts we get, when the duty cycle is 50% the output voltage is same as input voltage, when the duty cycle is less than 50% the output voltage is less than input voltage and when the duty cycle is more than 50% the output voltage is more than input voltage which satisfies our theoretical design.

## IV. CONCLUSION

This model presents a simple but efficient photovoltaic system with maximum power point tracking. This model almost provides an efficiency of 90% to 95%.

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